Electronic Supplementary Material (ESI) for Chemistry Education Research and Practice.

Appendix 1

Activities	Science	Technology	Engineering	Mathematics
Electrolytes	Differentiating electrolytes and non-electrolytes. Knowing the properties of electrolytes as containing ionic compounds and conducts electricity. Relating the free-moving ionic compounds with electrical conductivity.	Collaboratively engaged in designing the packaging of the isotonic drinks. A computer-generated prototype was first proposed. Using the available materials attempt was made to convert the virtual image to the real product. Multiple testing and improvements were made to get the best results.	Solving the engineering problem on inventing natural isotonic drink. Based on the ammeter readings, using engineering thinking decide the possible combinations of fruits and vegetables that result in best isotonic drinks.	Relating the ammeter reading with the current produced by the electrolytes (the juices). Associating the current (reading of ammeter) with the volume of electrolyte and mass of the fruits. The above information were used to determine the ratio of mixtures in preparing the recipes for isotonic drinks.
Electrolysis of Molten substances	Understanding the electrolysis of molten substances. Knowing the electrodes (anode and cathode). The movement of ions (anions and cations) and discharging of the ions at the electrodes. Using half-equations to represent the discharging process at the anode and cathode and complete ionic equation to explain the entire electrolysis process	Collaboratively engaged in exploring the electrolysis of various molten substances to identify the appropriate substances to be used to solder the LED bulbs. Communicated the findings of exploration and prepared a prototype of the circuit. Improvement on the prototype was made before deciding on the final circuit.	Solving the problem on using the iron ores available at the welding shops to solder the LED bulb and finally lit the bulb. An electrolysis process was designed for purifying the iron ore. Engineering design and thinking were employed in producing an electronic circuit using the iron from the electrolysis of iron ore to solder the LED bulbs to light the bulbs.	Relating the voltage-current needed for electrolysis and the mass of the product produced at the cathode. Using the above information determine the amount of iron ores for electrolysis so that an appropriate amount of iron would be obtained to solder the LED bulbs. Balancing half equations and ionic equations to relate the amount of starting material to the product.

The Four STEM Disciplines in the Five Integrated STEM-lab activities

Electrolysis of Aqueous solution	Understanding the electrolysis of aqueous solution. Knowing the electrodes (anode and cathode). The movement of ions (anions and cations) and factors influence the selection of ions to be discharged at the electrodes. These include positioning in electrochemical series; concentration of ions and the electrodes used.	Collaboratively in groups explored the electrolysis of aqueous solution with different concentrations and using different electrodes. In exploring the various materials, identified suitable solutions for the ionic therapy foot machine. The final prototype of the machine was determined after multiple rounds of testing using combinations of various solutions and using tubs with different sizes and depth to deliver the best results.	Solving the problem of designing a cost-effective Ionic foot detoxification machine which functions using the electrolysis process. Employed the fundamentals of electrolysis process (including the factors influences the discharge of ions) collectively with engineering design thinking (deciding on the materials, size and the structure) a prototype of the machine was prepared.	Relating the volume and concentration of the electrolytes with the amount of product obtained at the electrodes. Balancing half equations and ionic equations to relate the amount of starting material to the product. The above information was used in calculating the size and depth of the machine.
Electroplating a metal	Understanding electroplating and the purpose of electroplating a metal (iron key). Knowing the electrolysis process underlies the electroplating. Identify suitable electrodes and electrolytes for electroplating a metal (iron key).	Collaboratively in groups explored the electroplating of various metals with different sizes and shapes. Multiple investigations performed to understand the influences of type, size, and shape on the electroplating rate. Propose a prototype on solar energy electrolysis cell using the above information.	Solving the engineering problem on inventing solar energy electrolysis cells using readily available materials to plate a rusting iron nail. Using the mineral water bottles, copper rods, solar panels, the wires, and nails a cell was designed to cover the nail.	Deciding the volume and concentration of electrolyte needed to electroplate the metals. Relating the volume and size with the amount of electrode erodes and deposits at the anode and cathode to decide on the solar electroplating.
Metal Purification	Understanding purifying metal involves electrolysis. Knowing the processes that happen at anode and cathode to decide on the electrodes (impure metal as an anode and pure metal as a cathode) and the electrolyte.	Collaboratively in groups involved exploring impurities in metals. The metals with impurities were purified using electrolysis. Manifolds of try-outs performed using readily available materials to decide on the suitable electrodes and electrolytes for the water purifier. The prototype was tested/retested adjusting the concentration of electrolyte, the distance between electrodes and using different electrodes to decide on the optimal product.	Solving the engineering problem on inventing water purifier to remove the impurities such as chlorine in the local water supply. Guided by the fundamental principles underlies electrolysis engineering design thinking was applied in suggesting the water purification machine.	Deciding the volume and concentration of electrolyte needed to purify a certain amount of water. Regulate and calculate the ratio of the volume of water to the product and electrodes that results in an optimal product.